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# Analysis of Cuckoo Search with Genetic Algorithm for Image Compression

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**Abstract**
**Compressing an image is different than compressing raw binary data. Of course, general purpose compression Techniques can be used to compress images, but the result is less than optimal. Statistical properties of image have been exploited by encoders specifically designed for them. This also means that lossy compression techniques can be used in this area. In this paper, cuckoo algorithm is integrated with genetic algorithm in image compression framework. Here image compression is implemented with the combination of cuckoo search and genetic algorithm optimization with Discrete Cosine Transform (DCT). The experimental result clearly shows that the efficiency proposed image compression method is better than other based on statistical parameter of PSNR, MSE and CR.**
**Key words: Cuckoo search (CS), Genetic algorithm (GA), Discrete Cosine Transform (DCT), Image Compression**

## I. Introduction

With the ever growing technology, image compression is momentous to handle vast amount of image data and needs to be stored in a proper way by exploiting efficient techniques that normally succeed in compressing the images. Image compression is termed as the representation of an image by reducing the amount of data. Moreover, the ultimate goal of image compression is to reduce both spatial and spectral redundancy to accumulate or transmit data in a proper manner. Once the image is compressed it needs to be reconstructed at the receiver side to reproduce the source image.

. Optimization algorithms are needed to solve real-world optimization problems which are more complex. In all optimization problems, the goal is to find the minimum or maximum of the objective function. Thus, unconstrained optimization problems can be formulated as minimization or maximization of the D-dimensional function:

$$\text{Min (or max) } f(x), x = (x_1, x_2, x_3, \ldots x_D) \quad (1)$$

where D is the number of parameters to be optimized. Many population based algorithms are proposed for solving unconstrained optimization problems. Genetic algorithms (GA), particle swarm optimization (PSO), and bee algorithms (BA) are the most popular optimization algorithms which employ a population of individuals to solve the problem on hand. GA is one of the most popular evolutionary algorithms in which a population of individuals evolves (moves through the fitness landscape) according to a set of rules such as selection, crossover and mutation [i].PSO algorithm is another example of population based algorithms [ii]. PSO is a stochastic optimization technique which is well adapted to the optimization of nonlinear functions in multidimensional space and it has been applied to several real-world problems [iii].Several metaheuristics have been proposed to model the specific intelligent behavior of honey bee swarms [iv], [v], [vi], [vii]. The bee swarm intelligence was used in the development of artificial systems aimed at solving complex problems in traffic and transportation [v]. That algorithm is called bee colony optimization metaheuristic (BCO), which is used for solving deterministic combinatorial problems, as well as combinatorial problems characterized by uncertainty. The artificial bee colony (ABC) algorithm is relatively new population based meta- heuristic approach based on honey bee swarm [viii]. In this algorithm possible solution of the problem is represented by food source.

The cuckoo is the best known brood parasite, an expert in the art of cruel deception. Its strategy involves stealth, surprise and speed. The mother removes one egg laid by the host mother, lays her own and flies off with the host egg in her bill. The whole process takes barely ten seconds.

The genetic algorithm is a method for solving both constrained and unconstrained optimization problems that is based on natural selection [viii]. It is categorized as a stochastic algorithm. GA is especially efficient when the search space of a problem has very rough landscape riddled with many local optima.

Image compression technique using Cuckoo Search gives lower performance in terms of image quality metrics like PSNR. With that concern, an effective image compression technique using Cuckoo Search with Genetic Algorithm is proposed. It acts as a more promising way of compressing texture images. The image compression technique Cuckoo Search with Genetic Algorithm is well suited for accomplishing better performance in terms of PSNR. The performance of Cuckoo Search compression technique and Cuckoo Search with Genetic Algorithm image compression method is analyzed. An overview of the proposed model is projected Fig.1.

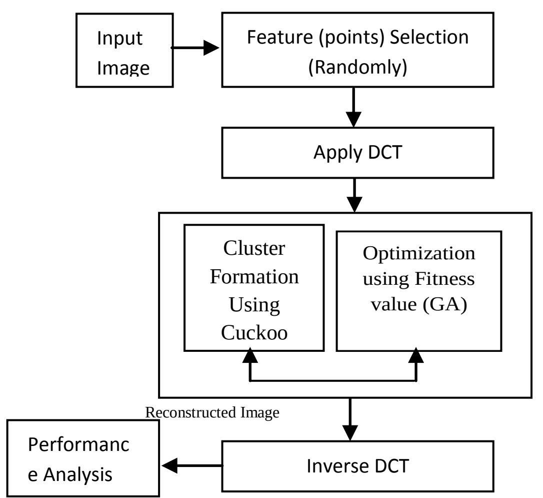



**Fig 1.Overview of the proposed model**

The rest of the paper is composed as follows: Section 2 reviews the related works of Cuckoo Search compression techniques. Section 3 describes Cuckoo Search with Genetic Algorithm and percolates a comparative study of Cuckoo Search compression technique with the Cuckoo Search with Genetic Algorithm approach for compressing the images. Experimental analysis is discussed in section 4. Finally, section 5 sums up the paper with conclusion and further direction.

## II. Related Works

As the word optimization suggests, the most outstanding goal in such procedures is saving both the computational time and the materials to achieve an optimum solution. During the last decades, several optimization methods were proposed including mathematical and metaheuristic algorithms. The latter methods which emerged as effective tools for global searching problems include some well-known approaches used for optimum design of steel frames. Genetic algorithms (GAs) inspired from Darwin's natural selection theorem based on the idea of the survival of the fittest [i]; A population based algorithm entitled Cuckoo Search (CS), inspired by the behavior of some Cuckoo species in combination with Lévy flight behavior [viii], is selected to optimize self-weight of three inclusive steel structures with the same structural system on two perpendicular directions. Structural models are analyzed and designed in accordance with AISC-LRFD specifications and displacement constraints. Cuckoo Optimization Algorithm (COS) suitable for continuous nonlinear optimization problems, is introduced. This optimization algorithm is inspired by the life of a bird family, called Cuckoo. Special lifestyle of these birds and their characteristics in egg laying and breeding has been the basic motivation for development of this new evolutionary optimization algorithm. Similar to other evolutionary methods, Cuckoo Optimization Algorithm (COA) starts with an initial population.

## III. Image Compression Approaches using Optimization

Optimization is the process of making something better. In other words, optimization is the process of adjusting the inputs or characteristics of a device, mathematical process, or experiment to find the minimum or maximum output or result. The input consists of variables: the process or function is known as the cost function, objective function, or fitness function; and the output is the cost or fitness. There are different methods for solving an optimization problem. Some of these methods are inspired from natural processes. These methods usually start with an initial set of variables and then evolve to obtain the global minimum or maximum of the objective function. Genetic Algorithm (GA) has been the most popular technique in evolutionary computation research. Genetic Algorithm uses operators inspired by natural genetic variation and natural selection.

Evolutionary optimization algorithm which is inspired by lifestyle of a bird family called cuckoo is introduced. Specific egg laying and breeding of cuckoos is the basis of this optimization algorithm which is combined with genetic algorithm. Cuckoos used in this modeling exist in two forms: mature cuckoos and eggs. Mature cuckoos lay eggs in some other birds' nest and if these eggs are not recognized and not killed by host birds, they grow and become a mature cuckoo. Environmental features and the immigration of societies (groups) of cuckoos hopefully lead them to converge and find the best environment for breeding and reproduction. This best environment is the global maximum of objective functions. From output of cuckoo search, GA is performed and forms the clusters of features and then DCT is applied to GA algorithm. This paper illustrates how the life method of cuckoos is modeled and implemented. This cuckoo optimization technique was used in image compression with the combination of DCT algorithm.

### 3.1 Image Compression Using Cuckoo Search Algorithm

The cuckoo is the best known brood parasite, an expert in the art of cruel deception. Its strategy involves stealth, surprise and speed. The mother removes one egg laid by the host mother, lays her own and flies off with the host egg in her bill. The whole process takes barely ten seconds. Cuckoos parasitize the nests of a large variety of bird species and carefully mimic the color and pattern of their own eggs to match that of their hosts. Each female cuckoo specializes on one particular host species. How the cuckoo manages to lay eggs to imitate each host's eggs so accurately is one of nature's main mysteries. Many bird species learn to recognize a cuckoo egg dumped in their own nest and either throws out the strange egg or desert the nest to start afresh. So the cuckoo constantly tries to improve its mimicry of its hosts' eggs, while the hosts try to find ways of detecting the parasitic egg. The struggle

between host and parasite is akin to an arms race, each trying to out-survive the other. For the cuckoos suitable habitat provides a source of food and a place to breed, for brood parasites the need is for suitable habitat for the host species.

CS is a heuristic search algorithm which has been proposed recently by Yang and Deb [1]. The algorithm is inspired by the reproduction strategy of cuckoos. At the most basic level, cuckoos lay their eggs in the nests of other host birds, which may be of different species. The host bird may discover that the eggs are not its own and either destroy the egg or abandon the nest all together. This has resulted in the evolution of cuckoo eggs which mimic the eggs of local host birds. For simplicity in describing the Cuckoo Search, the CS is implemented with these three rules:

• Each cuckoo lays one egg at a time, and dumps it in a randomly chosen nest;

• The best nests with the best of eggs (solutions) will move on to the next generations;

• The number of available host nests is fixed, and the cuckoo egg may be discovered with a probability $\rho_\alpha$ from [0, 1]. If discovered the nest is replaced by a new nest with random solutions. The Cuckoo Search Algorithm Image compression is exposed in Fig.2.

**STEP 1:** Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest (initialize points in an image). Objective function f(x), x=$(x_1, x_2, \ldots x_u)^T$.Initialize image Generating initial population of n host nests $x_i$ Where, (i=1,2,…n)

**STEP 2:** The best nests with high quality of eggs will carry over to the next generation (select the fitness points in an image)

While (t<Max Generations) and (! termin.condit.)

Move a cuckoo randomly

Evaluate its fitness Fi

Randomly choose nest among n available nests (for example j)

**STEP3:** The number of available hosts nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability $\rho_\alpha \in (0,1)$.(collecting matching points and rearrange the points until satisfied fitness value)

If(Fi > Fj) Replace j by the new solution;

Fraction of worse nests is abandoned and new nests are being built; Keep the best solutions or nests with quality solutions; Rank the solutions and find the current best.

End while

Post process and visualize results

End

**Fig.2.Cuckoo Search Algorithm for Image Compression**

### 3.2 Genetic Algorithm

A Genetic Algorithm (GA) is a search heuristic that mimic the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic Algorithms belong to the larger class of Evolutionary Algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as mutation, selection, and crossover.

This algorithm is based on the natural selection process seen in nature .The best fit organism of the current generation carries on the genes to the next generation. The concept of genetic operators (cross-over and mutation) is included in the algorithm where a change in the gene structure is introduced that produces an entirely different trait. The main idea behind genetic algorithm is the operators used namely reproduction, crossover and mutation. This algorithm takes a predetermined number of random solutions (population) in the search space called chromosomes.

**Initial population:** Its role is to hold (represent) possible solutions.

**Selection:** It could be done in two ways: Fitness proportional selection and rank-based selection. In the first one the selection probability depends on the absolute fitness value of the individual(solution) compared to other individual and in the latter it preserve the constant pressure by sorting the population on the basis of fitness and then allocating selection probability according to rank [8]. Variation operators: these operators create new individual (solution) by selecting one or more individual from population.

**Mutation:** this operator use only one parent and create one child by applying some kind of randomized change to the representation.

**Crossover:** is a process whereby a new individual solution is created from the information contained within two or more parent solution.

**Fitness function:** It defines what improvement means and assigns a quality measure to a chromosome and evaluates it.

Fitness = $\frac{f(x)}{f(sum)}$

(2)

Where $f(x)$ is the fitness entity $x$, and $f(sum)$ is the total fitness of all entities.

Here the convergence criterion is used to terminate the algorithm. At each iteration the chromosomes are made to crossover using single point crossover and the fitness of each chromosome. The clusters individually and $n$ is the population size. The fittest chromosomes (solutions) among

the entire population are considered for the next generation (iteration). At any random point the chromosomes undergo mutation based on the mutation rate. The fitness is calculated and the best solutions carry on till a termination criterion is reached. Thus the cluster centers are generated using the training data set. The Pseudo-code for Genetic Algorithm is given in Fig.3.

1. Initialize population of *n* chromosomes
2. Repeat till stopping criteria
   a) Calculate fitness
   b) Apply elitism by sorting the fitness value of the population
   c) Retain the best fit solutions (reproduction)
   d) Crossover the adjacent chromosomes at a random position.Using single point crossover
   e) Mutate randomly selected point within a chromosome
3. Cluster centre will be the best fit solution from the population

**Fig. 3 Pseudo-code for Genetic Algorithm**

In this algorithm the task of finding the best domain block for each and every range block is carried out by the Genetic Algorithm (GA), which results in to the fast compression of the image.

**3.3 Image Compression Using Cuckoo Search with Genetic Algorithm**

The proposed (CS with GA) approach exploits the use of cuckoo with genetic algorithm to efficiently reconstruct the image from the original image.The parameters, γ and $\alpha$ introduced in the CS help the algorithm to find globally and locally improved solutions, respectively. The parameters $P\alpha$ and $\alpha$ are very important parameters in fine-tuning of solution vectors, and can be potentially used in adjusting convergence rate of algorithm. The traditional CS algorithm uses fixed value for both $P\alpha$ and $\alpha$. These values are set in the initialization step and cannot be changed during new generations. The main drawback of CS method appears in the number of iterations to find an optimal solution. If the value of $P\alpha$ is small and the value of $\alpha$ is large, the performance of the algorithm will be poor and leads to considerable increase in number of iterations. If the value of $P\alpha$ is large and the value of $\alpha$ is small, the speed of convergence is high but it may be unable to find the best solutions. The key difference between the CS with GA and CS is in the way of adjusting $P\alpha$ and $\alpha$. To improve the performance of the CS algorithm and eliminate the drawbacks lies with fixed values of $P\alpha$ and $\alpha$, the CS with GA algorithm uses variables $P\alpha$ and $\alpha$ .In the early generations, the values of $P\alpha$ and $\alpha$ must be big enough to enforce the algorithm to increase the diversity of solution vectors.

$$P_a(gn) = P_{a\,max} - \frac{gn}{NI}(P_{a\,max} - P_{a\,min}) \quad (3)$$

$$\alpha(gn) = \alpha_{max}\ exp(c.gn) \quad (4)$$

$$c = \frac{1}{NI} Ln\left(\frac{\alpha_{min}}{\alpha_{max}}\right) \quad (5)$$

However, these values should be decreased in final generations to result in a better fine-tuning of solution vectors. The values of $P\alpha$ and $\alpha$ are dynamically changed with the number of generation and expressed in Equations (3) and (5), where NI and given equation are the number of total iterations and the current iteration, respectively.

The working procedure of the proposed scheme is halved into the process namely, selection of input image (Original image),randomly select the feature points, apply DCT, cluster can be formed using Cuckoo Search ,then the fitness values are optimized using Genetic Algorithm, last apply the Inverse DCT in Reconstructed Image. The following Fig.4 shows Algorithm for cuckoo Search with Genetic Algorithm.

**3.3.1 Image Reconstruction**

The DCT compression algorithm is summarized below:

- A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.
- The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient, whereas for differential equations the cosines express a particular choice of boundary conditions.
- By using DCT, encode the cluster from output of cuckoo optimization algorithm.
- It provides inversion of DCT algorithm to decode the compressed image. The output from IDCT was cluster formation of output which was encoded.

In the encoding process of DCT, the image is broken down into K*K blocks of pixels, where K denotes 2, 4, 6, etc. The DCT computation for a sequence *f(i)* of

$$D(u) = \alpha(u)\sum_{i=0}^{K-1} f(i)\cos\left[\frac{\pi(2i+1)u}{2K}\right] \quad (6)$$

Where, u is a range from 0 to K-1 and the DCT coefficients is *D (u)*. The Inverse DCT (IDCT) is expressed as,

$$(i) = \sum_{u=0}^{K-1} \alpha(u)D(u)\cos\left[\frac{\pi(2i+1)u}{2K}\right] \quad (7)$$

**Step 1:** Each cuckoo lays one egg at a time, and dumps its egg in a randomly chosen nest (initialize points in an image).

Objective function f(x), x= $(x_1, x_2, \dots x_u)^T$

Initialize image

Generating initial population of n host nests xi.Where, (i=1,2,…n)

**Step 2:** The best nests with high quality of eggs will carry over to the next generation (select the fitness points in an image)

While (t<Max Generations) and (! termin.condit.)

Move a cuckoo randomly; Evaluate its fitness Fi

Randomly choose nest among n available nests (for example j)

**Step 3:** The number of available hosts nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability $\rho_\alpha \in (0,1)$ (collecting matching points and rearrange the points until satisfied fitness value)

If(Fi > Fj) Replace j by the new solution;

Fraction point of worse nests are abandoned and new nests are being built;

Keep the best solutions or nests with quality solutions; Rank the solutions and find the current best

End while

Post process and visualize results

End

**Step 4: Outline of the Basic Genetic Algorithm**

**[Start]** Generate random population of *n* chromosomes

**[Fitness]** Evaluate the fitness *f(x)* of each chromosome *x* in the population

**[New population]** Create a new population by repeating following steps until the new population is complete

**[Selection]** Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)

**[Crossover]** With a crossover probability cross over the parents to form a new offspring (children). If no crossover was performed, offspring is an exact copy of parents.

**[Mutation]** With a mutation probability mutate new offspring at each locus (position in chromosome).

**[Accepting]** Place new offspring in a new population

**[Replace]** Use new generated population for a further run of algorithm

**[Test]** If the end condition is satisfied, **stop**, and return the best solution in current population

**[Loop]** Go to step **2**.

{

Initialize population; Calculate fitness function;

While (fitness value != termination criteria)

{

Selection; Crossover; Mutation;

Calculate fitness function;}}

Where, i=0, 1 …K-1 and $\alpha(u) = \begin{cases} \sqrt{\frac{1}{K}} & when\ u = 0 \\ \sqrt{\frac{2}{K}} & otherwise \end{cases}$.

The DCT coefficients are obtained from each block of input data. The DCT is having best energy compaction capability for highly correlated images. At the receiver, the projections are decoded by IDCT and the same is used to reconstruct the image. While input the image a cuckoo search algorithm calculate and displays the cost value and cuckoo iteration of the image. The DCT Algorithm encode the image and final output of cost value and Iteration.

**Fig.4. Algorithm for CS with GA**

## IV. Experimental Results and Discussions

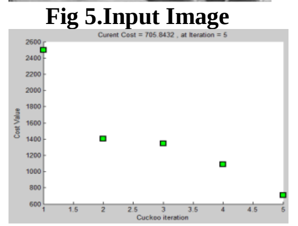
The Cuckoo Search and CS with GA have been implemented using Matlab, and then these two algorithms are compared with each other using the ten selected images.







**Fig 5.Input Image** **Fig 6.Reconstructed Image**



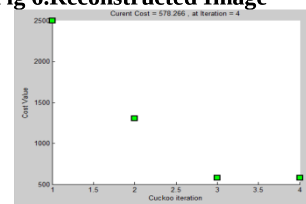
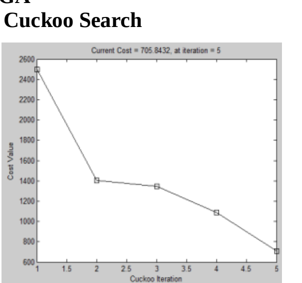




**Fig 7.Cuckoo Iteration for Cuckoo Search** **Fig 8. Cuckoo Iteration for CS with GA**



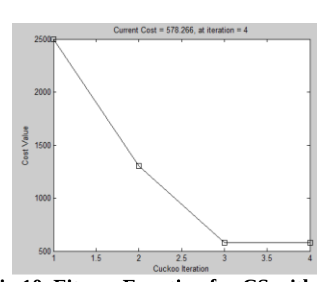




**Fig 9.Fitness Function for Cuckoo Search** **Fig 10. Fitness Function for CS with GA**

Fig. 7 and 8 shows the Selection of features in Cuckoo Search with CS with GA respectively. The Selection of features is done randomly. So the cost values change according to random selection. The Genetic Algorithm optimization is used to decrease the number of iterations. From Fig 9 and 10 represents the Cost of fitness function .Fig 6, it is obvious that reconstructed image is obtained.

The image statistics namely, MSE (Mean Squared Error) and PSNR (Peak Signal to Noise Ratio) afford the performance measure of an image compression technique. Based on this

statistics an efficient image compression technique that is well suited for texture images are determined. Image quality is measured by means of PSNR between the original image and reconstructed image. The PSNR value is computed in dB using the equation given below:

$$PSNR = 10\, log_{10} \frac{I^2}{MSE} \quad (8)$$

Where MSE is Mean Square Error and I is the pixel intensity level of an image. The MSE is defined in equation (9). It produces the distortion level by comparing reconstructed and original image.

$$MSE = \frac{1}{AB} \sum_{i=1}^{A} \sum_{j=1}^{B} (P_{i,j} - Q_{i,j})^2 \quad (9)$$

Where P is the original image of size A x B and Q is the reconstructed image of size A x B.

**Table 1. Sample MSE and PSNR value for the Cuckoo Search**

| | CS with GA | | | Cuckoo search | | |
|---|---|---|---|---|---|---|
| Images | MSE | PSNR | CR | MSE | PSNR | CR |
| Baboon | 0.01 | 66.36 | 22 | 0.0313 | 63.17 | 28 |
| Barbara | 0.012 | 67.3 | 28 | 0.025 | 64.11 | 30 |
| Goldhill | 0.012 | 67.26 | 30 | 0.012 | 67.26 | 32 |
| leena | 0.014 | 66.58 | 15 | 0.02 | 64.07 | 16 |
| walkbridge | 0.013 | 66.99 | 46 | 0.027 | 63.8 | 46 |
| living room | 0.013 | 66.83 | 28 | 0.028 | 63.64 | 32 |
| lake | 0.016 | 66.07 | 36 | 0.033 | 62.87 | 37 |
| woman blonde | 0.163 | 66.01 | 28 | 0.034 | 62.81 | 29 |
| pirate | 0.012 | 67.34 | 24 | 0.025 | 64.15 | 21 |
| peppers | 0.0115 | 67.52 | 23 | 0.024 | 64.33 | 27 |
| Average | 0.0265 | 66.82 | 25.9 | 0.02353 | 64.02 | 26.9 |

**CS with GA**

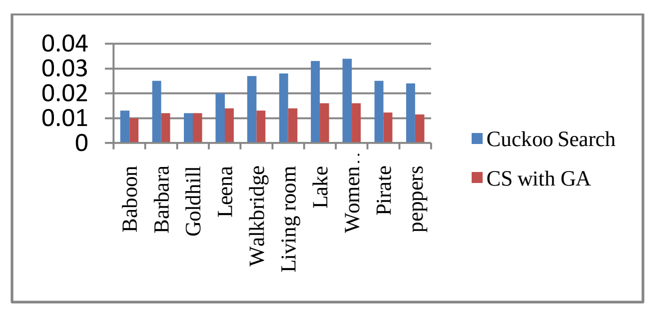



**Fig.12 MSE (dB) comparison of Cuckoo and Cuckoo with GA**

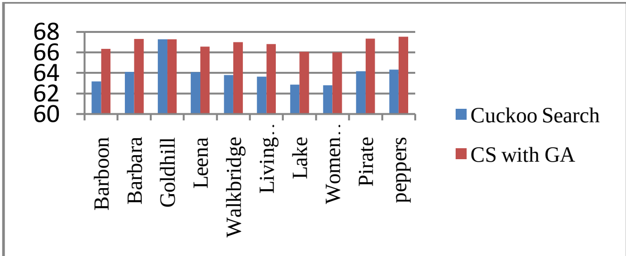



**Fig.13 PSNR and MSE Values of CS and CS with GA**

The compression ratio (CR) is measured using the expression is,

$$CR = \frac{\textit{size of the image being compressed}}{\textit{size of the source image}} \quad (10)$$

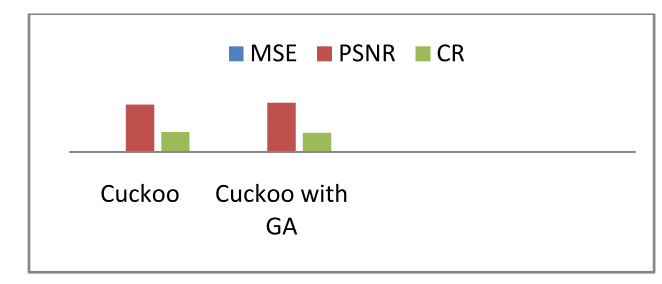



**Fig.13 Comparison chart for CS and CS with GA**

The MSE and PSNR value are computed between the original image and reconstructed image in order to measure the performance of proposed image compression scheme. The computation is carried out using the equation (8) and (9). The MSE and PSNR value of Cuckoo Search image compression technique is 0.02353 and 64.02dB. Whereas the MSE and PSNR value of CS with GA image compression technique is 0.0265 and 66.82 dB respectively.

By comparing the performance of these two image compression techniques using performance criteria, it is shown that Cuckoo Algorithm's image compression using CS with GA accomplish greater PSNR value than the image compression using Cuckoo Algorithm. Experimental results reveal that image compression CS with GA scheme achieves excellent reconstructed image quality than the Cuckoo Algorithm.

## V. Conclusion

A novel technique for image compression, CS with GA is proposed for random features selection in DCT which is used to encode the images. The comparative analysis of image compression techniques using CS and CS with GA are performed. Each technique has its own pros and cons. Experimental results expose the performance of proposed image compression technique that accomplishes high PSNR value and compression ratio as compared to the existing image compression technique. Based on the perspective of high image quality on reconstructed image, the proposed work outperforms other techniques.

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